XX. *An Analyſis of Two Mineral Subſtances*, viz. *the* Rowley-rag-ſtone *and the* Toad-ſtone. *By* William Withering, *M. D.*; *commuicated by* Joſeph Prieſtley, *LL. D. F. R. S. to Sir* Joſeph Banks, *Bart. P. R. S.*

Read May 16, 1782.

TO SIR JOSEPH BANKS, BART. F. R. S.

DEAR SIR,

Birmingham, Oct. 1, 1781.

I HAVE the pleaſure to lay before you an analyſis of two mineral ſubſtances by Dr. WITHERING of Birmingham, whoſe accuracy in proceſſes of this kind will, I doubt not, give you and the members of the Royal Society great ſatisfaction.

It may, perhaps, throw ſome additional light on the ſubject of theſe foſſils to inform you, that the Rowley-rag appears, by its texture before and after fuſion, and alſo by the quantity and quality of the air which it yields in fuſion, to be the ſame thing with the baſaltes with which you have favoured me from Scotland; and that the Toad-ſtone, treated in the ſame manner, appears (after the calcareous part has been diſſolved out of it) to reſemble ſome of the ſpecies of lava, except that it yields much more air. As Dr. WITHERING has ſent ſpecimens of the foſſils in their natural ſtate, I thought it might not be amiſs to preſent along with them the *glaſſy ſubſtances* into which they are reduced by fuſion.

I am, with the greateſt reſpect, &c.

J. PRIESTLEY.

TO DR. PRIESTLEY.

SIR, Birmingham, March 28, 1782.

I NOW ſend you the reſults of my examination of the Toad-ſtone and the Rowley-rag-ſtone; being part of a plan which I have long ſince formed for a chemical analyſis of all the ſubſtances that are known to exiſt in the earth in large quantity.

Some years ago I tranſmitted to the Royal Society an analyſis of the different marles found in Staffordſhire, which they did me the honour to inſert in their Tranſactions; if they think theſe papers likewiſe worth their adoption, I ſhall ſend them the reſults of my future inquiries.

In the courſe of experiments which this ſubject has led me to, I found it convenient to form ſome new tables, and to enlarge ſome that were leſs completely formed before. Theſe tables will be uſeful in other branches of chemical inquiry. One of them I ſubjoin to the preſent papers. The facts taken from M. MACQUER are marked with an M; thoſe with the * are the conſequence of my own experiments.

In order to ſave much repetition in future, it may not be amiſs to mention, once for all, a few particulars in the conduct of theſe proceſſes.

1ſt, By *water*, is always meant water diſtilled in glaſs veſſels, or by means of a large tin refrigeratory in Mr. IRWIN's method.

2dly, Only glaſs or china veſſels are uſed in the liquid proceſſes.

3dly, By a mortar I mean thoſe excellent ones made by Mr. WEDGEWOOD; or, as will be ſpecified at the time, a ſteel mortar

mortar tempered ſo hard that it will bear the grinding of enamel in it without diſcolouration.

4thly, Filtres are never employed, it being found impoſſible to get the quantities accurate where they are uſed. The powdery parts are allowed to ſubſide until the ſupernatant liquor becomes clear. This ſometimes requires days or weeks; but I am ignorant of a better method. By giving the veſſels a circular motion round their axes, I can greatly facilitate the ſubſiding of the ſolid contents. If the ſeparating veſſels are made like a common tart-diſh, with a ſpreading border, the liquors may be poured off very near, without diſturbing the ſediments.

5thly, Phlogiſticated alkaly means the vegetable fixed alkaly prepared by the deflagration of nitre and cryſtals of tartar diſſolved in water, and boiled with Pruſſian blue in ſuch quantity that it will not any longer precipitate an earth from an acid.

I remain, &c.

W. WITHERING.

ROWLEY-RAG.

THE ſtone which is the ſubject of the following experiments forms a range of hills in the ſouthern part of Staffordſhire. The lime-ſtone rocks at Dudley bed up againſt it, and the coal comes up to the ſurface againſt the lime-ſtone. The higheſt part of the hills is near the village of Rowley. The ſummit has a craggy, broken appearance, and the fields on each ſide to a conſiderable diſtance are ſcattered over with large fragments of the rock, many of which are ſunk in the ground. In a quarry near Dudley, where a pretty large open-

ing has been made in order to get materials for mending the roads, the rock appears to be compoſed of maſſes of irregular rhomboidal figures: ſome of theſe maſſes incloſe rounded pebbles of the ſame materials. At the diſtance of four, five, or ſix miles from the hills, as at Bilſton, Willenhall, and Wedneſbury, the Rag-ſtone is frequently found ſome feet below the ſurface in rhomboidal pieces, forming an horizontal bed of no great depth, and ſeldom of more than a few yards extent. Over the whole of this tract of country it is uſed to mend the roads, and lately has been carried to Birmingham to pave the ſtreets. Some people ſell it in powder, as a ſubſtitute for emery in cutting and poliſhing.

MORE OBVIOUS PROPERTIES.

Its appearance dark grey, with numerous minute ſhining cryſtals. When expoſed to the weather gets an ochry colour on the outſide; ſtrikes fire with ſteel; cuts glaſs; melts, though not eaſily, under the blow-pipe. Heated in an open fire becomes magnetic, and loſes about 3 in 100 of its weight.

EXPERIMENTS.

A. After three drams had been broken to ſmall pieces with a hard ſteel hammer, upon a plate of the ſame metal, it was ground to an impalpable powder in one of Mr. WEDGEWOOD's China mortars. The mortar, which had been previouſly weighed, loſt only one-third of a grain weight during this operation.

B. This powder was repeatedly waſhed with pure water, ſo as to carry off all the finer parts, and the coarſer ground again, until

until the whole was waſhed away. The waſhings were then filtered, and the powder carefully collected and dried. The water employed in the waſhings did not appear to have diſſolved any part of the ſtone; for no precipitate was formed either upon the addition of mild fixed alkaly, or of ſilver diſſolved in the nitrous acid.

C. 100 parts of this powder were put into a ſmall mattraſs, and covered with marine acid: a degree of heat was excited, and a very ſlight effervescence took place. Water was then added, and the mixture kept boiling for half an hour. The liquor was decanted off, and more acid added, which was boiled as before. This was decanted, and the reſiduum waſhed with water until the water came off taſteleſs. Theſe waters were added to the liquors before decanted. The powder had now an aſh-coloured appearance, and when dried weighed 80¼.

To the liquors (C) phlogiſticated fixed alkaly was added, until no more Pruſſian blue was precipitated. To effect this it took one ounce, five drams, and twelve grains of the phlogiſticated alkaly. The precipitate, when waſhed and dried, weighed 47.

E. The powder of 80¼ (C) mixed with twice its weight of foſſile fixed alkaly, was put into a black lead crucible, and expoſed to a red-heat for two hours. The heat was never ſufficient to render the maſs fluid, nor to make it adhere firmly to the crucible. The ſaline part was then waſhed away by repeated effuſions of hot water. To the remaining powder marine acid was added repeatedly, and boiled as before. The powder was now perfectly edulcorated by hot water, and when dry weighed 47½.

The above liquors were all added to the liquor (C), and phlogiſticated fixed alkaly was dropped in, until no more Pruſſian

blue was precipitated. To effect this, half an ounce of the alkaly was required. This precipitate weighed 19; ſo that the whole of the Pruſſian blue weighed 66. After calcination in a crucible it was reduced to $31\frac{1}{2}$, and was then wholly attracted by a magnet.

F. Mild fixed alkaly was now gradually added to the liquors after the ſeparation of the Pruſſian blue, and a white powder was precipitated. This powder, when well waſhed and dried, weighed $46\frac{3}{4}$. After being expoſed to a low red-heat for ten minutes, it weighed only $32\frac{1}{2}$.

G. The edulcorated powder (E) was now perfectly white; was not acted upon either by the vitriolic, nitrous, or marine acids, but readily melted into a glaſs with foſſile fixed alkaly; during the melting an effervescence took place.

H. The white powder (F) readily diſſolved in diluted vitriolic acid, and under a ſlow evaporation formed cryſtals which had the appearance and the taſte of allum.

Theſe cryſtals were then reduced to powder, and boiled in alcohol. The alcohol was decanted off, but did not appear to have diſſolved any part of the powder; nor did it afford any precipitate upon the addition of mild fixed alkaly.

CONCLUSIONS.

From theſe experiments it appears, that the Rowley-rag-ſtone conſiſts of ſiliceous earth, clay, or earth of allum, and calx of iron. From the latter muſt be deducted $11\frac{1}{2}$ for the quantity of calciform iron, found by experiment to be contained in the quantity of phlogiſticated alkaly made uſe of, and then the proportions in 100 parts of the ſtone will be theſe:

4 Pure

Pure ſiliceous earth -	47½
Pure clay, free from fixable air	32½
Iron in a calciform ſtate -	20
	100

From this view of the component parts of this ſtone, it is not improbable, that it might advantageouſly be uſed as a flux for calcareous iron ores. The makers of iron are acquainted with ſuch ores; but never could work them to advantage, for want of a cheap and efficacious flux.

TOAD-STONE.

FROM Derbyſhire; ſent to me by Mr. WHITEHURST, who has ſo fully and ſo accurately deſcribed the mode of its ſtratification, that it is needleſs to enlarge upon that ſubject.

MORE OBVIOUS PROPERTIES.

Of a dark browniſh grey, a granulated texture; with ſeveral cavities filled with cryſtallized ſpar. It does not ſtrike fire with ſteel. It melts to a black glaſs.

EXPERIMENTS.

A. 100 parts rubbed to an extremely fine powder in a china mortar, and boiled in marine acid; the ſolution was decanted: the undiſſolved part, after proper waſhing and drying, weighed 71.

B. The undiſſolved part was rubbed with twice its weight of mild foſſil alkaly, and then expoſed to a red heat in a black lead crucible for one hour.

C. This mixed maſs was reduced to powder, and repeatedly boiled, firſt in marine, afterwards in ſtrong vitriolic acid: the reſiduum now weighed 56, and was perfectly white.

D. The liquors of exp. A. and C. being put all together, phlogiſticated fixed alkaly was added until no further precipitation enſued. This precipitate was a Pruſſian blue, which, when waſhed and dried, weighed $56\frac{5}{10}$.

After expoſure to a red-heat in a crucible for forty minutes, it weighed only 29, and was wholly attracted by the magnet.

Now the 2 oz. 5 dr. and 32 gr. of phlogiſticated fixed alkaly uſed in this experiment contain 13 gr. of calciform iron, as aſcertained by a ſeparate trial; therefore, deducting 13 from 29, we have 16 for the quantity of calciform iron obtained from the ſtone.

E. The earthy parts were next precipitated from the liquors by the addition of mild foſſil alkaly. The precipitate, when perfectly edulcorated and dried, weighed $29\frac{8}{10}$.

F. Diſtilled vinegar was added to this powder, and ſuffered to ſtand in a cool place for four hours; the vinegar was poured off, and the reſiduum repeatedly waſhed with pure water. To theſe liquors mild fixed alkaly was added, and a white precipitate ſubſided, which, when waſhed and dried, weighed $7\frac{5}{10}$.

G. To the reſiduum (F) dilute vitriolic acid was added: a ſolution took place, which ſolution, by evaporation and cryſtallization, yielded allum.

H. The part of the reſiduum (F) undiſſolved by the vitriolic acid was boiled in nitrous acid, in marine acid, and in aqua regia, without being diminiſhed; the weight of it when dried

was

was $7\frac{5}{10}$. It could not be fuſed by the greater heat of a blow-pipe, but melted into a glaſs when mixed with calcareous earth.

I. The undiſſolved part (exp. C.) was not fuſible by itſelf; nor was it acted on by vitriolic, nitrous, or marine acid. It melted into a glaſs with foſſil alkaly.

K. The precipitate of $7\frac{5}{10}$ (exp. F.) after a ſufficient expoſure to heat was put into an ounce of water: the next morning the water had a pellicle upon its ſurface, and taſted like lime-water.

CONCLUSIONS.

Hence it appears, that 100 parts of this ſpecimen of Toad-ſtone contained

C. Siliceous earth	56	$63\frac{5}{10}$
H. More ditto	$7\frac{5}{10}$	
D. Calciform iron		16
F. K. Calcareous earth		$7\frac{5}{10}$
G. H. Earth of allum		$14\frac{8}{10}$
		$101\frac{8}{10}$

From the addition of $1\frac{8}{10}$ of weight it is probable, that the ſubſtances capable of uniting with fixable air were not in the ſpecimen uſed fully ſaturated with it, as they would be after their precipitation by the mild alkaly.

Upon repeating theſe experiments with different portions of the Toad-ſtone, the quantities of the calcareous earth were found to differ a little; but nothing further appeared to invalidate the general concluſions.

A TABLE ſhewing the Solubility or Inſolubility of certain Saline Subſtances in Alcohol.

		Subſtances.	Reſults.
Vitriolic acid	Neutral	Vitriolated tartar	Inſoluble. M.
		Glauber's ſalt	Inſoluble. M.
		Vitriolic ammoniac.	Inſoluble. M.
	Metallic	Vitriol of ſilver	Inſoluble. M.
		—— mercury	Inſoluble. M.
		—— copper	Inſoluble. M.
		—— iron	Inſoluble. M.
		—— zinc	Inſoluble. *.
	Earthy	Heavy ſpar	Inſoluble. *.
		Selenite	Inſoluble. M.
		Allum	Inſoluble. *.
		Epſom ſalt	Soluble. *.
Nitrous acid	Neutral	Nitre	Soluble. M.
		Cubic nitre	Soluble. M.
		Nitrous ammoniac.	Soluble. M.
	Metallic	Nitre of ſilver	Soluble. M.
		—— mercury	Inſoluble. M.
		—— copper	Soluble. M.
		—— lead	Soluble. *.
	Earthy	Calcareous nitre	Soluble. M.

		Subſtances.	Reſults.
Muriatic acid	Neutral	Digeſtive ſalt	Soluble. M.
		Common ſalt	Inſoluble. M.
		Sal ammoniac.	Soluble. M.
	Metallic	Luna cornea	Inſoluble. M.
		Corroſ. Sublimate	Soluble. M.
		Muria cupri	Soluble. M.
		—— ferri	Soluble. M.
	Earthy	Muria calcarea	Soluble. M.
		—— magneſiæ	Soluble. *.
		—— aluminoſa	Soluble. *.
Vegetable acid	Neutral	Soluble tartar	Soluble. *.
		Rochelle ſalt	Inſoluble. *
		Veget. ammoniac.	
	Metallic	Verdigraſs	Soluble. *.
		Sugar of lead	Soluble. *.
Calcareous acid	Neutral	Veg. alkaly mild	Inſoluble. *
		Foſſ. alkaly mild	Inſoluble. *
		Vol. alkaly mild	Soluble. *.
		Calcareous ſpar	Soluble. *.